HYDRO CHEMISTRY MONITORING AND RISK ASSESSMENT OF MINING AND URANIUM TAILINGS IN THE TRANS-BOUNDARY RIVER WATERSHED IN CA COUNTRIES – TAJIKISTAN, KYRGYZSTAN AND KAZAKHSTAN

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NEW ISTC PROJECT

- New project of ISTC for the conduct of radio-ecological, hydro-chemical and geochemical investigation of pollution extension in transboundary areas of Central Asian river Basin, where main uranium, gas and gold mining industries is concentrated proposed. Study of the change dynamics of contamination by comparing the data obtained in the course of this project with the 15 years old date base of Navruz experiment will be conduct.

- The samples of waters, aqueous suspensions, surrounding soils, bottom sediments and vegetation's will be collected from the rivers to analyze concentration of isotope-chemical elements. The samples analyzed by the X-ray fluorescence analysis (XRF) and by gamma spectrometers in the domestic's laboratories and will be shipped to Alma-Ata for the neutron activation analysis.

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ECOLOGICAL SITUATION IN TAJIKISTAN

- Intensive development of the Syr-Darya and its basin began in 1944, as part of the uranium program of the former Soviet Union (USSR); a large-scale uranium- mining complex was created near Hodzhent (then Leninabad) in Tajikistan. A large processing plant for the extraction of uranium near Chkalovsk and integrated uranium concentration facilities in the Sogd area in Tajikistan were constructed.

- In addition, metallurgical complexes have been constructed in the watershed of the Syr-Darya to extract and refine iron, a wide variety of non-ferrous metals including antimony, mercury and tungsten, and precious metals including silver and gold. In Tajikistan, the extensive uranium mining activity in the Syr Darya basin has led to the creation of more than 5×10^7 tons of uranium mine tailings in ten locations covering more than 170 hectares with a total activity of more than 136 TBq (Mirsaidov, 2010).

ECOLOGICAL SITUATION IN KIRGIZSTAN

- In the upper courses of the Syr-Darya, in Kyrgyzstan, a large uranium mine was create along the Mailu-suu River.
- In 1958 in the territory of tailing depositories of Mayluu-Suu a large technogenic crash occurred (wash-out). As a result of this event more than 100 thousand cubic meter of uranium waste product was deposited in the waters of Mayluu-Suu and further on contaminated the Syr-Darya. Heavy metals, including thorium, molybdenum, selenium, arsenic and others could reach and produce to a bottom deposit in the Kayrakum water reservoir (Torgoev and Aleshin, 2010; Abdushukurov, 2014).

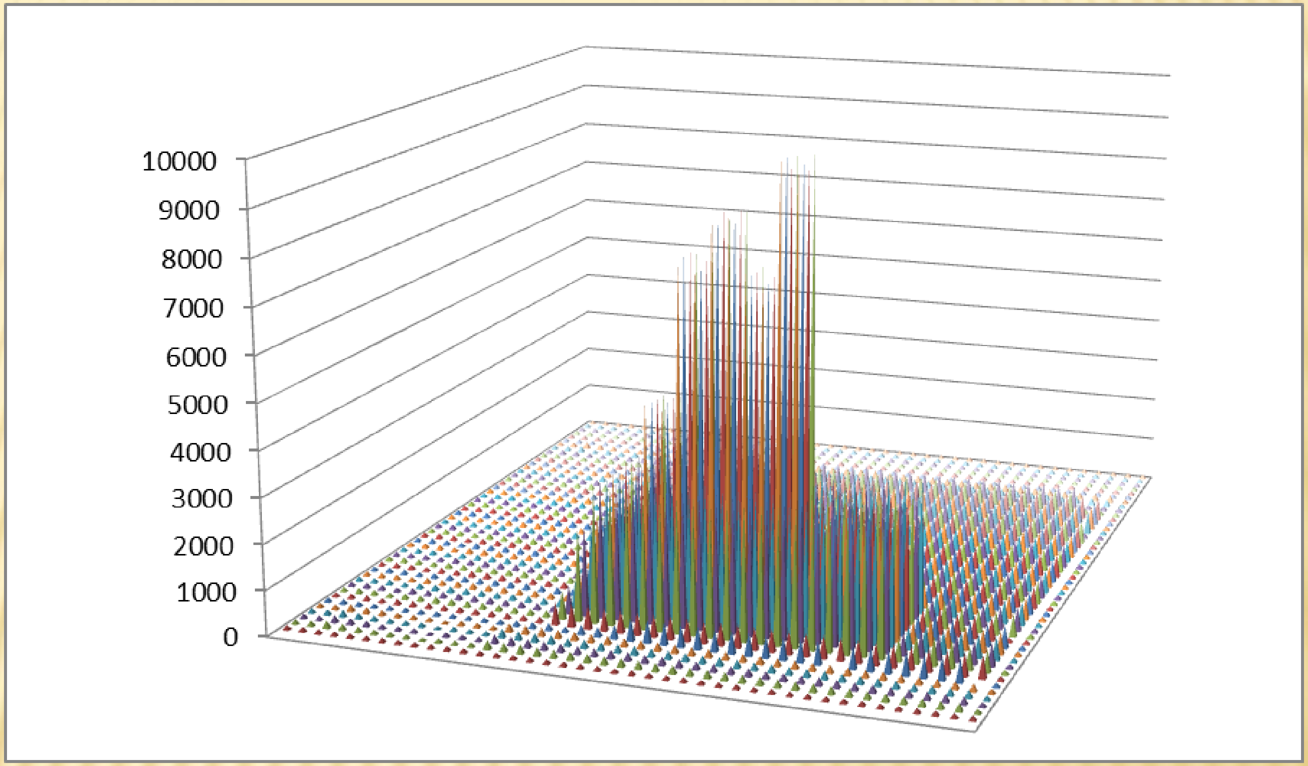
ECOLOGICAL SITUATION IN UZBEKISTAN

- Industrial development of Navoi mining complex for uranium ores started in 1958. The radioactive waste tailings are located on the left bank of Zerafshan River near Navoi. Sixty million tons of uranium waste are stored near Navoi Hydrometallurgical Plant Number 1. It is estimated that the total quantity of radionuclides in the tailing is about 160 thousand Ci. (Torgoev and Aleshin, 2010) Other uranium deposits are Sabyrsai, Yuzhny Kanimekh, Severny Maizak, Yuzhny Bukinai, etc.

DEGMAY TAIL DEPOSITORY

has an area of 90 hectares, located on the Degmay Upland - near the settlements Goziyon (at a distance of 1.5 km), Yova (9 km), and the Khujand city (14 km). In this tailing dump radioactive waste about 20 million cubic meters (or about 36 million tons) was buried.

GAMMA SHOOTING OF THE TAIL DEPOSITORIES



Three-dimensional histogram of the distribution of gamma-background in nSv / h on the surface of the tailings. It is clearly visible that the storage is divided into three parts. In the center there is a bare body of the tailings.

GAFUROV CITY TAIL DEPOSITORY

The tailing dump of the Gafurov city was buried according to all international standards. In 1991, the tailing dump was mothballed by a neutral soil 3.7 m thick, which eliminates radon exhalation exceeding the background value, and the dose rate of gamma radiation does not exceed 11-12 nSv / h, which is at the level of the natural background of this area.

ADRASMAN TAILING

In the photo red figures the Adrasman tailing dump, a red arrow indicates a gate in the abandoned mine.
Directly on the body of the tailings, the equivalent dose rate was from 200 to 700 nSv / h, but on the tailing body washout of the protective layer observed, where fixed values of 1470 nSv / h.

ISTICLOL TAILING

Dumps of the factory of poor ores.

EROSION OF TAILING

FLOODED QUARRY

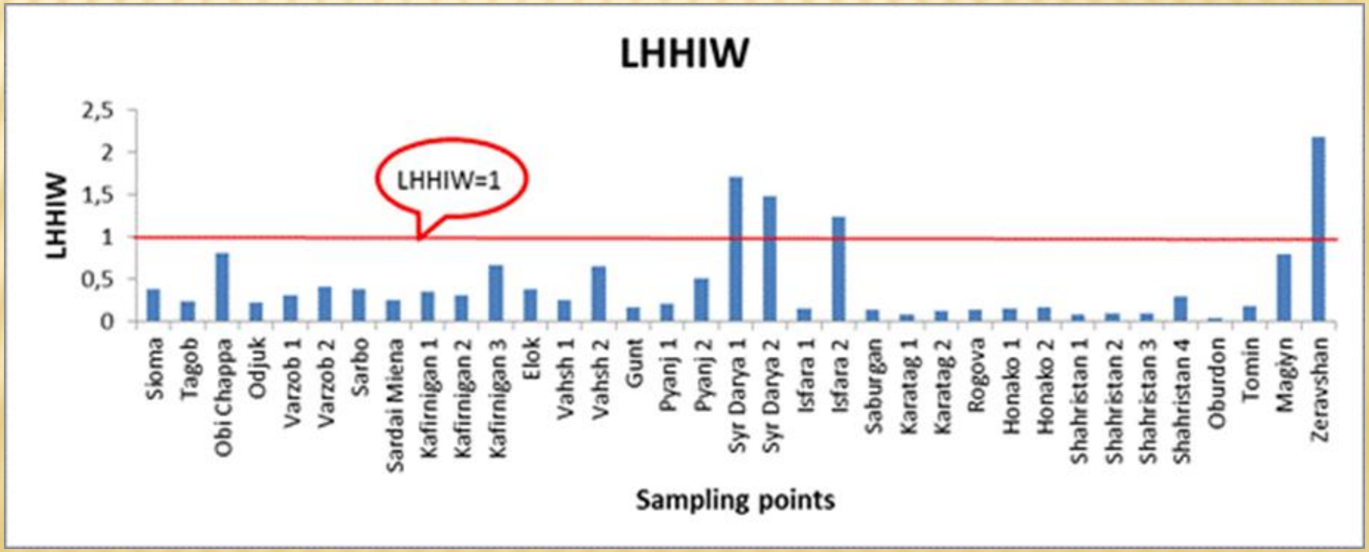
Flooded quarry where uranium ore was previously mined by open pit with depth more than 50m. The quarry is flooded with water, reeds grow along the banks. The maximum dose rate of gamma radiation was 0.38 µSv / h. According to local residents in a career children are swim and fishing.

ACCORDING DATE OF "NAVRUS" AND ISTC T-1000 PROJECT (2003-2006)

In the selected water samples concentrations of dissolved metals were measured. Among the elements were detected metals from hazard 1class: As, and 2 classes: Ba, Co, Mo, Na, Ni, Sb, Sr, Se and U.

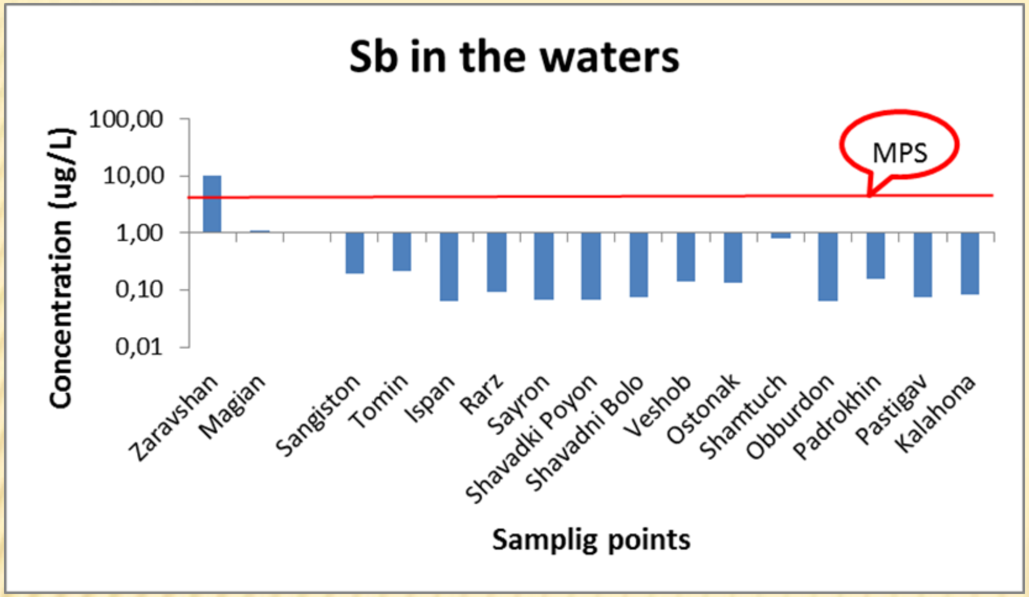
At presence in the waters of several metals from 1 and 2 hazard class the limiting health hazard indicator of water (LHHIW) presenting the sum of the ratio of concentration of metals to their MPC for several metals used (Hygienic rules).

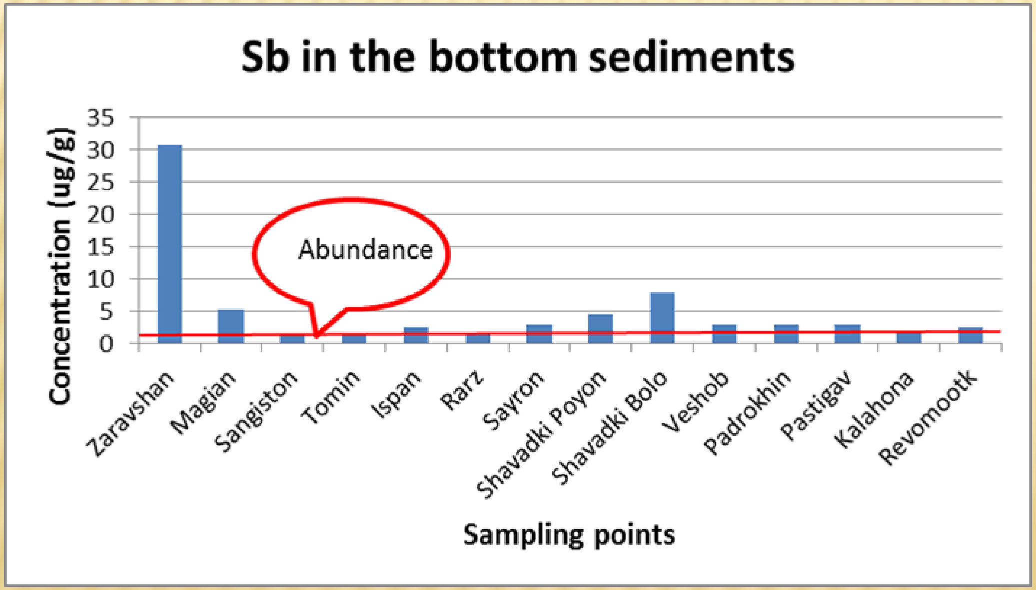
$$\mathrm{LHHIW} = \sum_{i=1}^{j} Ci/\,MPCi \leq 1$$



WATER CONTAMINATION

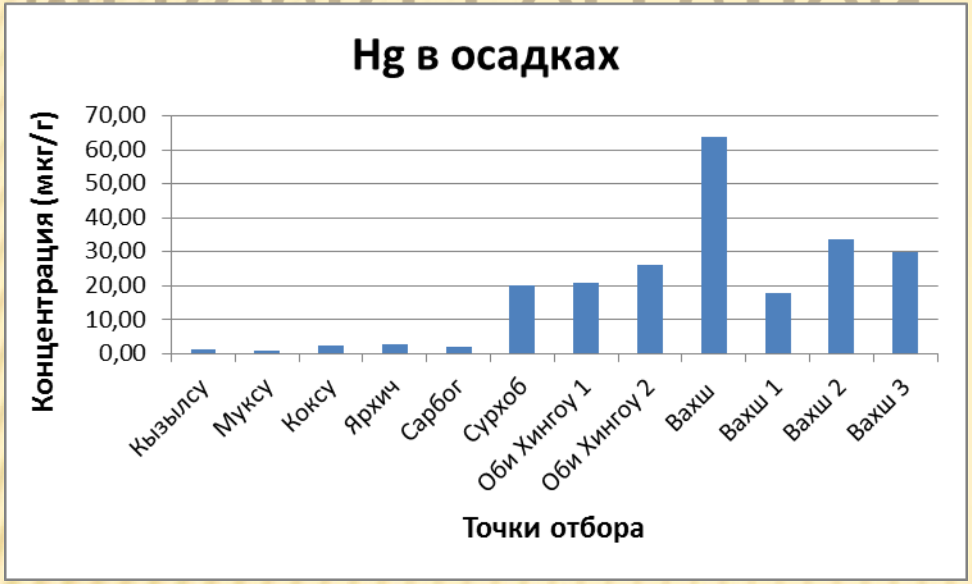
- Syr-Darya is transit River for Tajikistan, and flows through its territory, only about 180 km. Value of LHHIW at the entrance is higher than in its output (Abdushukurov D.A., et al., 2014) and it is associated with a positive effect on water quality in the river of Kayrakum reservoir.
- The water was dirty, also in the lower reaches of Isfara River on the border with Uzbekistan, LHHIW greater than 1. In general, pollution caused by the presence of three elements: Na, Se and U. Brackish of water in the lower reaches, due to the influence of drainage water from agricultural fields. Also, there is an increased concentration of selenium and uranium.

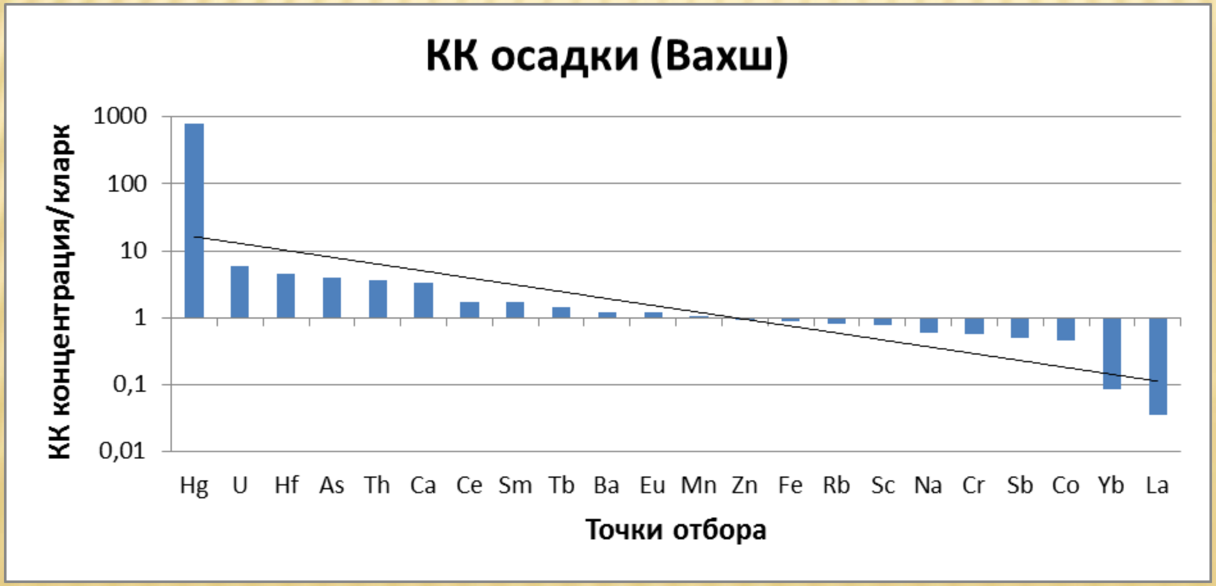




In water of Zeravshan significant content of Antimony (more than 2 MPC), was found. The water pollution source was Anzob Mining and Processing Plant specializing in the production of Mercury-Antimony concentrates. During the time of sampling the slurry pipeline of plant was broken and flotation tailings discharge in to river, at result the plant waste reach into the Yagnob River, hereinafter to Fan Darya and Zeravshan.

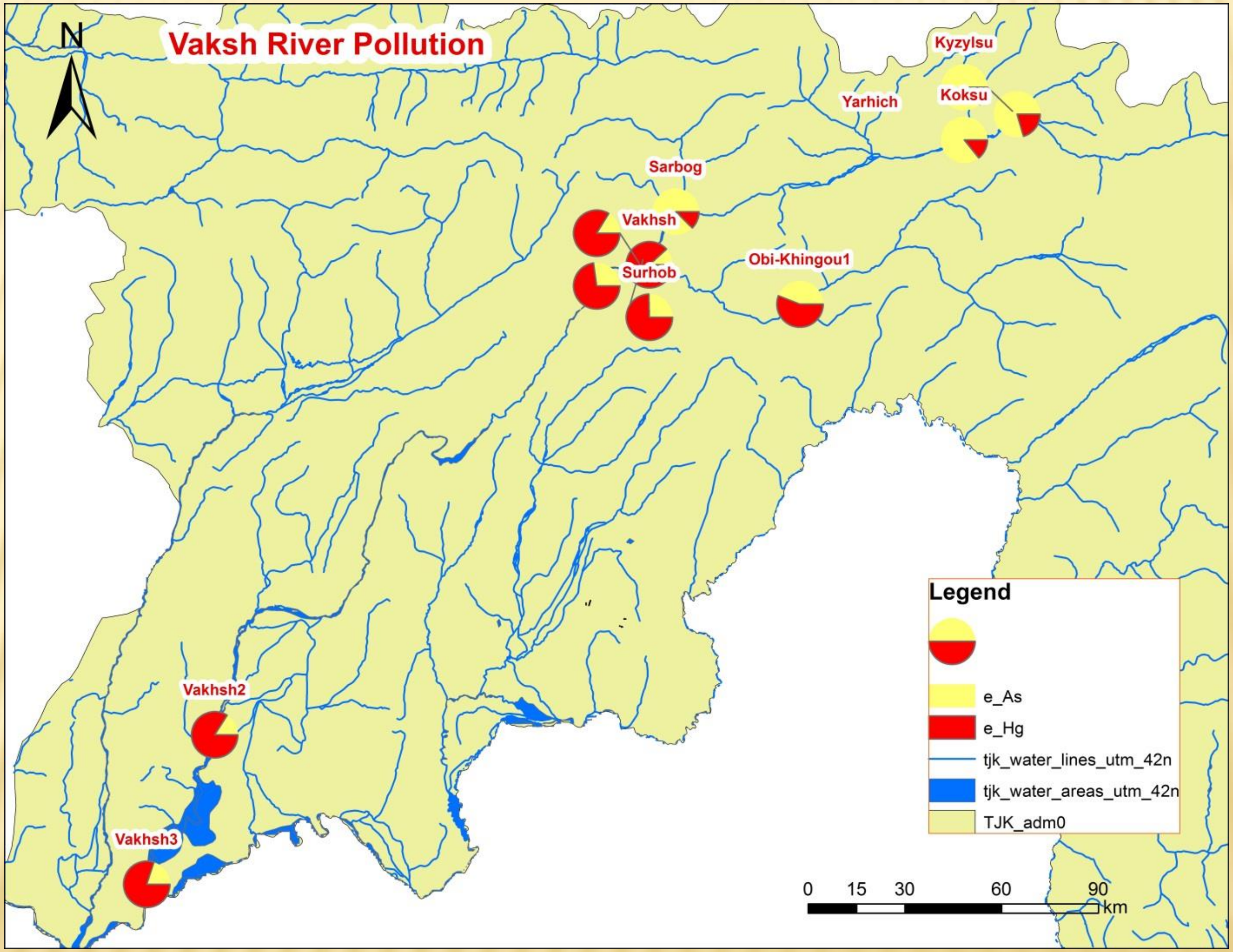
MERCURY POLLUTION





In the Vaksh river highly polluted with mercury sediments was found. Pollution has anthropogenic character and associated with legal and illegal mining of native gold. Mercury contamination is observed in all the rivers on which gold was mined. Such pollution in Tajikistan was revealed for the first time. The concentration of mercury in places exceeds 800 clarks or 30 MACs for soils. High concentration of mercury can be traced to the mouth of the Vakhsh River and is highest in gold mining areas.

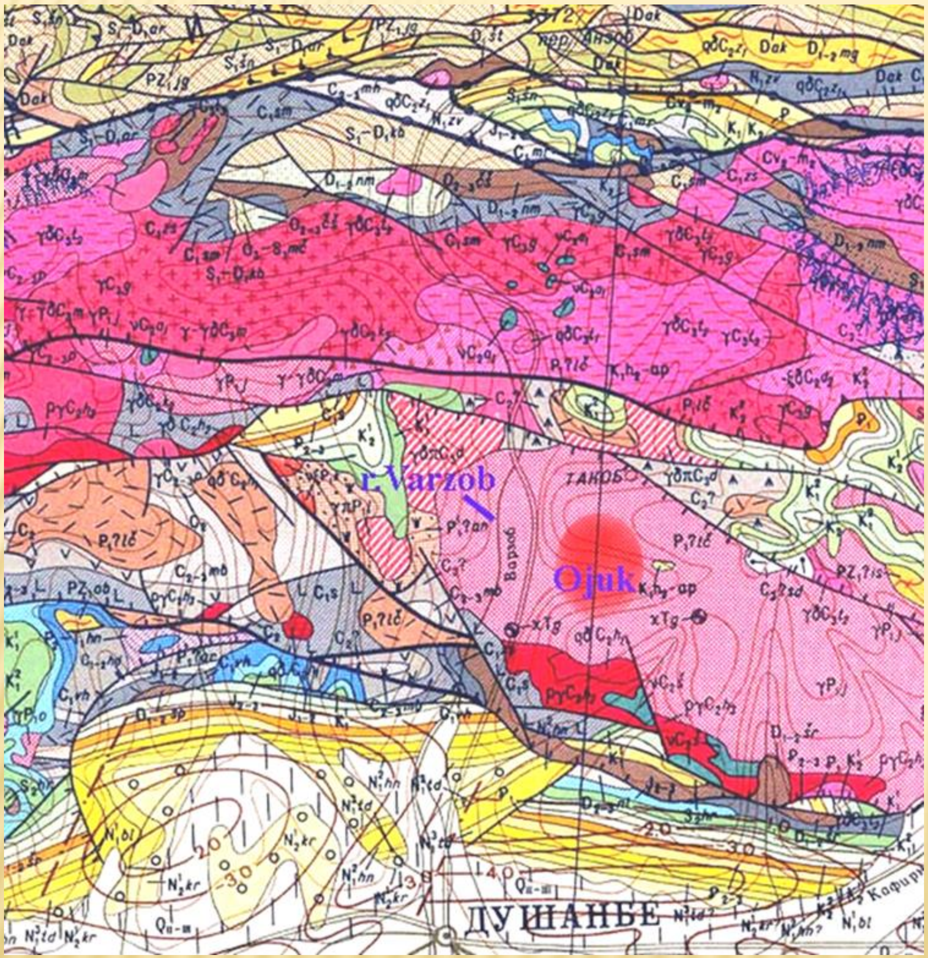
GIS MAP (AS AND HG POLLUTION)



ABNORMAL ISOTOPE PRECIPITATION IN THE MOUNTAINS

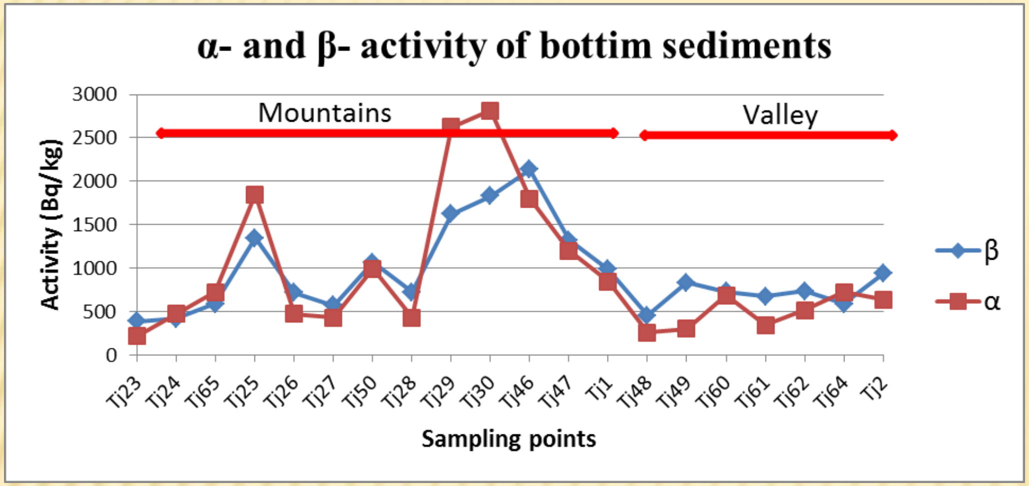
- Investigation of radioisotope distribution in the Varzob River basin, in Central Tajikistan was carried out. Two zones with an abnormally high concentration of radioactive isotope, in the composition of bottom sediments of river and coastal soils, were identified this is: a gorge of the Odjuk River and entrance to the gorge of Sioma River. High concentration of Thorium, Uranium and isotopes of Thorium-Uranium decay series in Odjuk River is due to the availability of the large pegmatite spots. The anomaly in the gorge of Sioma is linked by air transfer of radioactive isotope (Radon – 222 and Cesium - 137). The relief of the gorge leads to a sharp change of the direction of wind flows, which leads to an increased fall of aerosols, including isotopes.

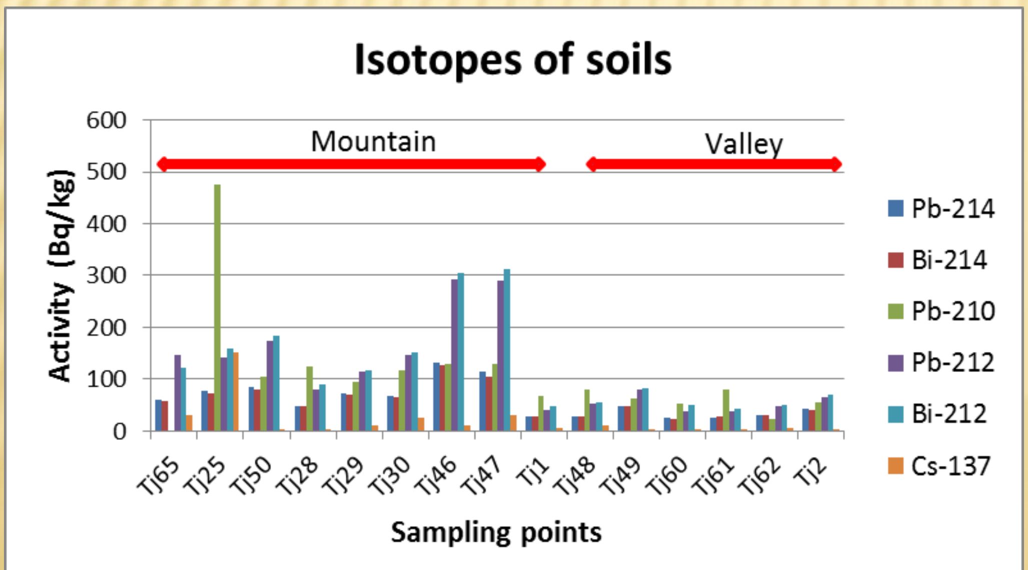
GEOLOGICAL MAP OF VARZOB RIVER BASIN



The basin of the Varzob River belongs by geologically to the South-Gisar structural-formational zone of Southern Tien-Shan. The basin is distinctly divided into two parts: the multi-phases Gissar batholith, with different granitites middle carboniferous - Early-Permian age, and in some places ruptured by early-Mesozoic dikes of lamprophyres and explosion tubes with alkaline basalts. To the south, at the outlet to the valley, located the Tajik depression, which is a zone of accumulation of sedimentary rocks of Mesozoic-Cenozoic age - continental and coastal-marine, terrigenous and chemogenics, sometimes coal-bearing, salt-bearings and gypsiferous rocks, which are intensively deformed during the collision of the alpine cycle during interaction Indo-Asian plate systems, continuing to this day.

DISTRIBUTION OF RADIOACTIVITY





In the valley the isotopes in the composition of the soil and bottom sediments are more or less distributed evenly. The main differences begin in the mountains. Two peaks of activity in Odjuk and Sioma are clearly visible. In Odjuk, mainly, there are isotopes of the Thorium series, and in the Sioma of the Uranium series.

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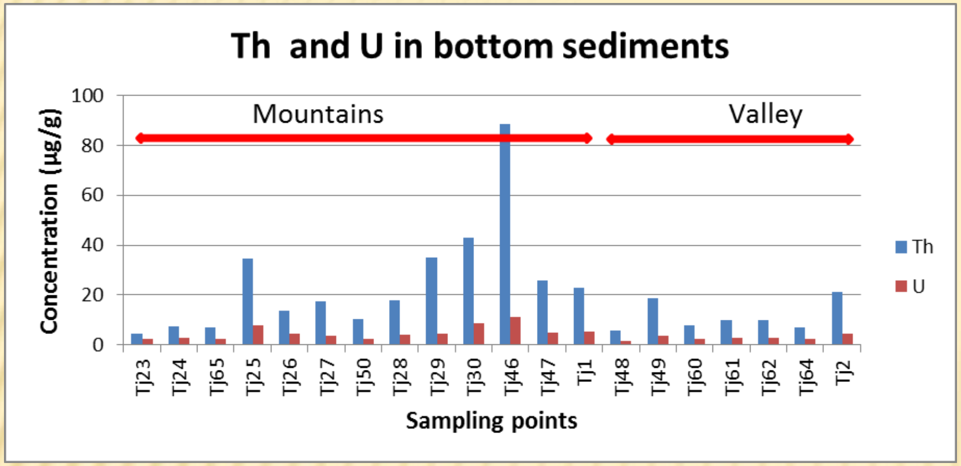
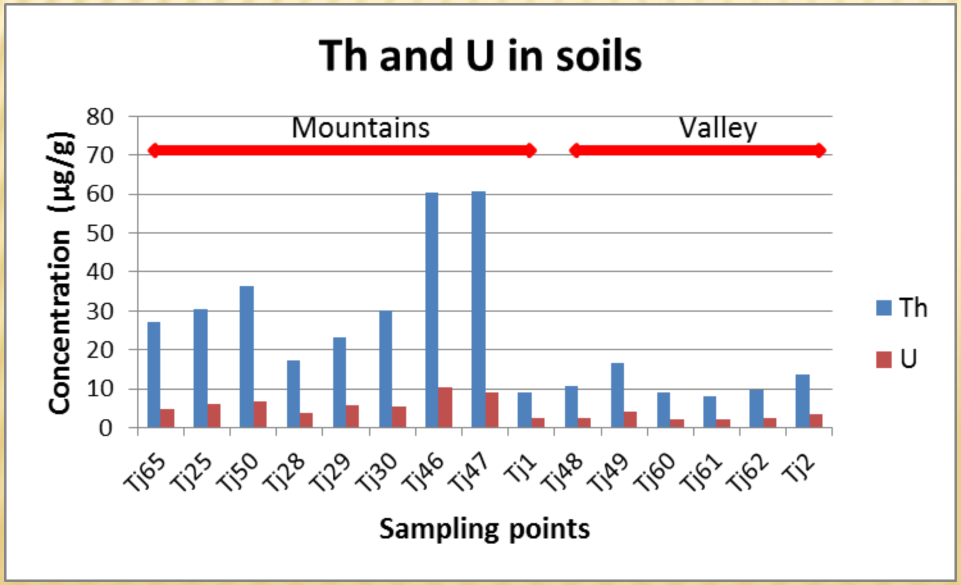
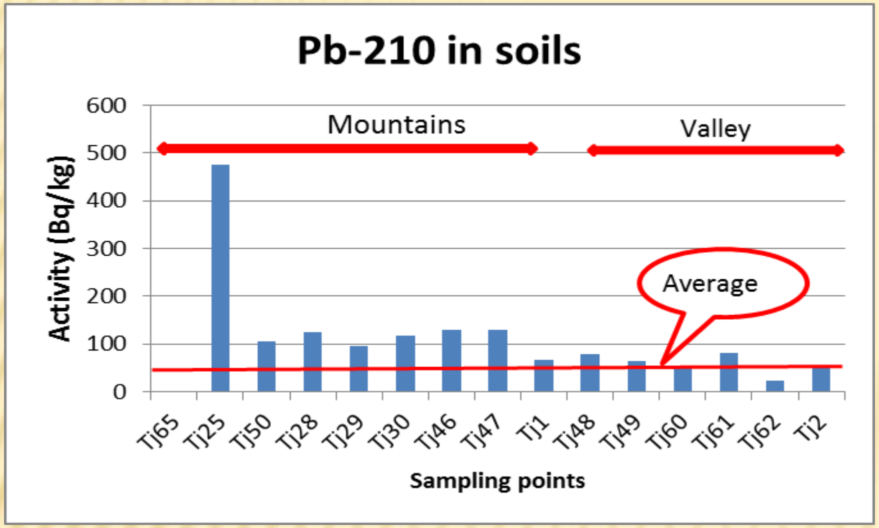
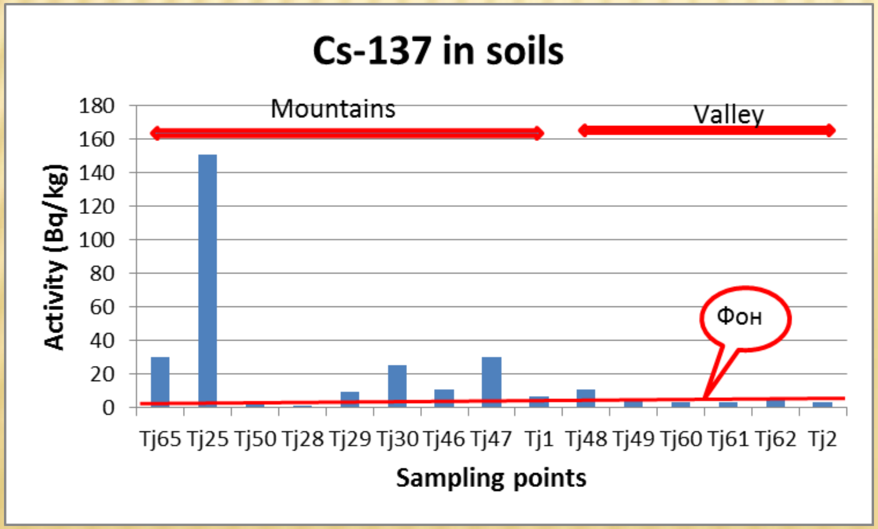




The distribution of Thorium and Uranium in soils repeats the distribution of their isotopes; although they are differ from the distribution of metals in the bottom sediments.

Separately were summed isotopes of Thorium and Uranium series showed a different correlations with Thorium and Uranium, so the correlation of the Thorium concentration with their isotopes is very high, r^2 = 0.99, and for Uranium and its isotopes is lower than r^2=0.72.

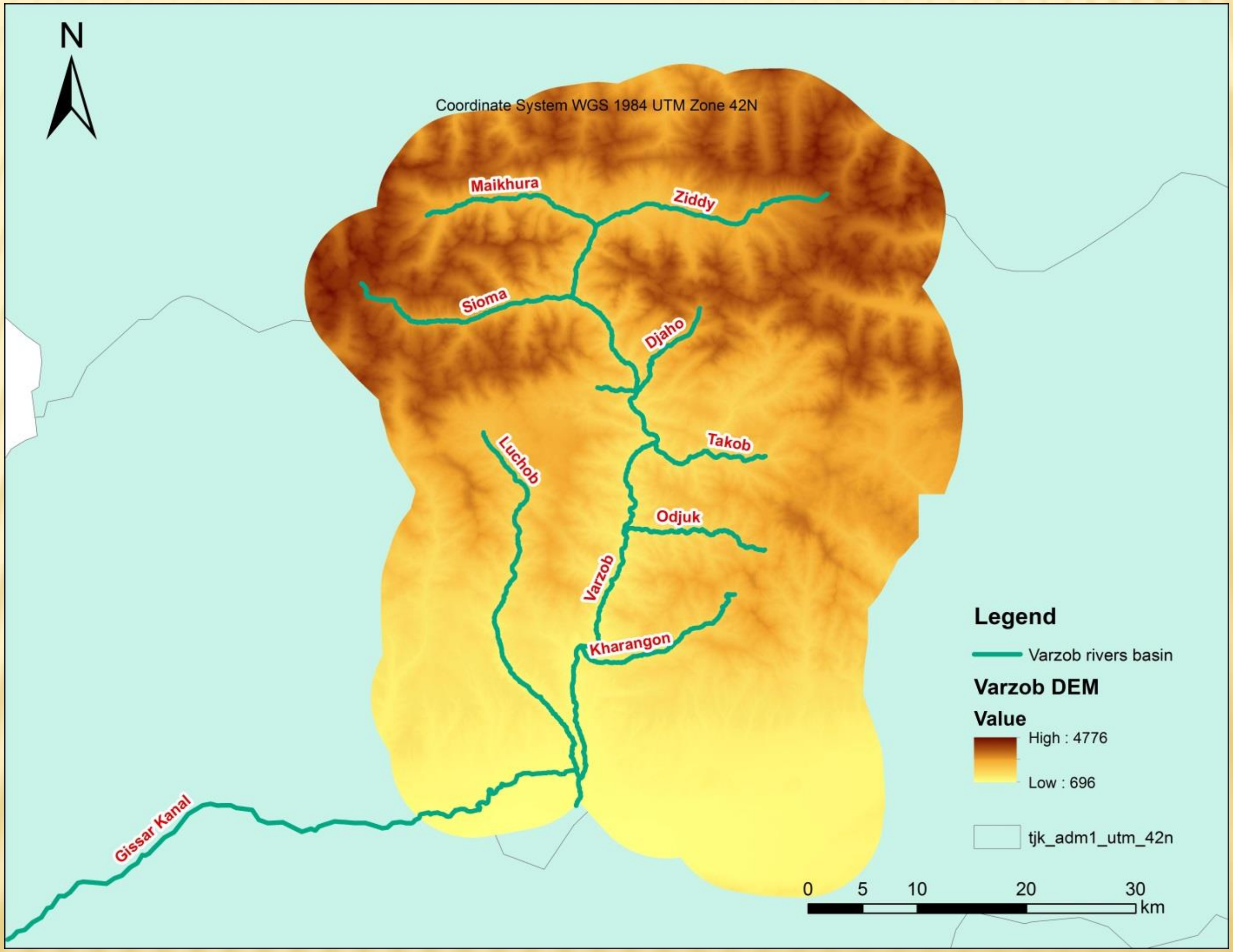




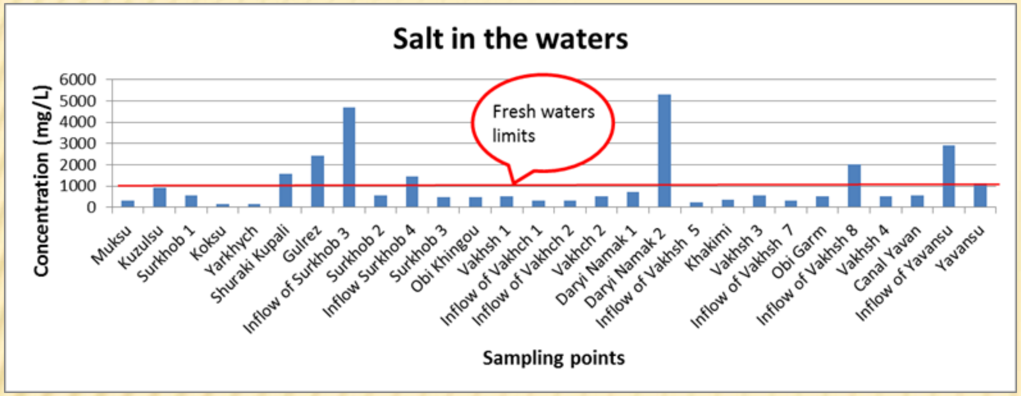
The isotopes Pb-212 and Bi-212 are daughter isotopes of Thoron (Rn-220), which has a half-life 55.6 sec . Such an insignificant lifetime of the Thoron can explain the anomalous accumulation of its daughter isotopes. The Odjuk pegmatite spot is saturated with Thorium, in the composition of the accessory minerals emanates the Thoron, which in a short time of life does not spread far and is absorbed by nearby soils and the river.

Radon (Rn-222) has a half-life of 3.8 days, usually accumulates in lowlands, in mountainous conditions near the surface of rivers, and in the presence of powerful wind currents can move in area. In the biosphere objects Radon is determined by the presence of its daughter isotope Pb-210 .

GIS MAP OF VARZOB RIVER



RESENT INVESTIGATION



In July 2017, expeditionary trip was carried out to the upper reaches of the Vakhsh River.

The water of the Kyzylsu River before the confluence with Muksu has an increased mineralization and is practically unsuitable for drinking water supply. The concentration of salts in it is practically equal to 1 g/L.

After confluence with the Muksu River, the concentration of salts decreases almost twice (Surkhob 1).

The several streams with a high concentration of salts flow into the left side of the Surkhob and Vakhsh rivers were fund. These are the Daryei Namak, Dashti Namak, Shuraki Kupali, Gulrez, Yavansu and others rivers. We detected 8 tributaries with a salt concentration of more than 1 g/L. The maximum salt concentration was found in the left-bank inflow of Vakhsh: Daryei Namak 5.3 g/L. Some streams directly pass through deposits of Jurassic salts.

SALINIZATION SOURCES

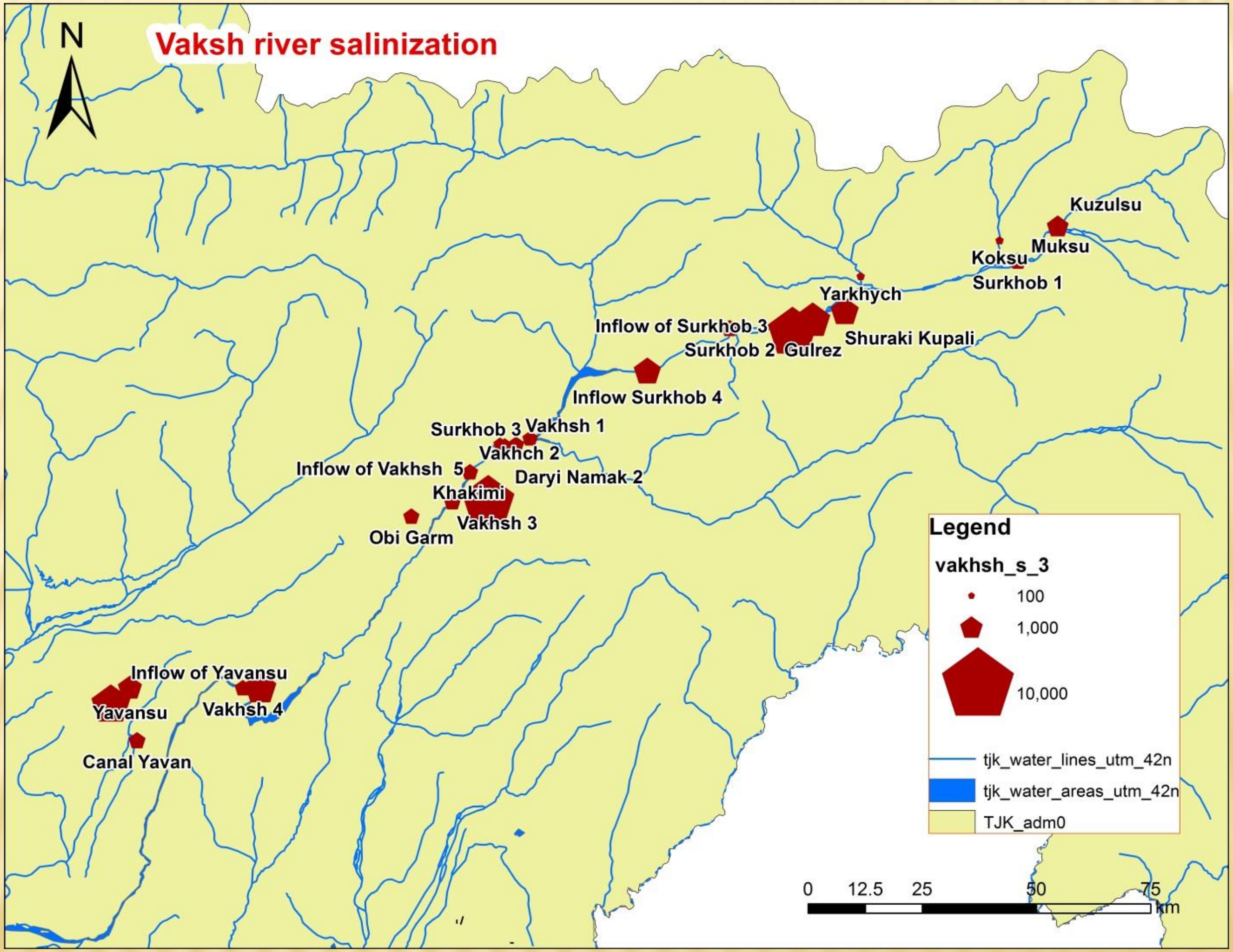
The problem of the initial salinization of Mountain Rivers in Tajikistan is very relevant. Salinity of small mountain rivers can be significantly reduced by using water line (pipes or canals), in highly mineralized zones. Such methods will reduce the overall salinity of the Vakhsh River, and the Amu Darya, respectively, and lie in the sphere of interest of many Central Asian countries.

At present, all achievements are being taken to reduce the secondary salinization of the Central Asian Rivers. Drainage constructions and evaporative lakes are being built (Toderich, 2004). But for the problem of primary salinization of rivers is not paid any attention.

SALT DEPOSITORIES

Exit the streams of water from the salt depository (Roguni Bolo)

GIS MAP OF SALINIZATION OF VAKSH



METHODS OF PROPOSED PROJECT

- To obtain an improved understanding of the environmental changes in land-water-ecosystem of Syr-Darya River and Amy-Darya River basins, the samples of water, aqueous suspensions, soil and vegetation will be collected from the river, its lateral inflows and other land sites to analyze concentration of isotope-chemical elements at the samples.
- The samples collected in the field research will be processed and analyzed by the X-ray fluorescence analysis (XRF) and by gamma spectrometers in the domestic's laboratories in Dushanbe and Bishkek. Part of samples processed and distributed into chemically clean jars, will be shipped to Institute of Nuclear Physics at Almaty and Institute Nuclear Physics at Tashkent for the neutron activation analysis (NAA). Both methods, the XRF and NAA will complement each other to analyze the 38 elements- major: Ca, Fe, K, Mn, Na, Ti and trace-elements: As, Au, Ba, Br, Ce, Co, Cr, Cs, Cu, Eu, Ga, Hf, La, Lu, Mo, Nb, Nd, Ni, Rb, Sb, Se, Sr, Sc, Sm, Ta, Th, U, V, Y, Yb, Zn, Zr. 14 elements, such as: K, Ti, Br, Cu, Ga, Mo, Nb, Nd, Ni, Se, Sr, V, Y, Zr, are determined only by XRF, the remaining elements are determined by the NAA method, or by two methods simultaneously . Elements with a concentration of <1 µg / g (ppm) can only be determined using NAA. The isotopes ^{137}Cs, ^{40}K, decay series of ^{238}U, ^{235}U, ^{232}Th will be determined by gamma spectrometers.

SCOPE OF ACTIVITIES AND EXPECTED RESULT

- **Scope of Activities:**
- Development of technical specifications, schedules, and routes of expeditions.
- Preparation and implementation of field work and sampling methods and protocols.
- Development of technical specifications for elemental analyses.
- Data processing and analyses including creation of GIS maps.
- Comparison of new results with the Navrus data.
- Report writing and development of recommendations.
- Scientific management of the project.
- **Expected result:**
- Identification of sites contaminated by radioactive isotopes, heavy and toxic metals and evaluation of the degree of pollution.
- Data base on the distribution of radioactive isotopes and geochemical of elements in soil, bottom sediments, waters and plants.
- Definition changing of pollution with radioactive isotopes and toxic metals water ecosystems of Central Asia in the time.
- Risk assessments and recommendations for mitigation actions.

THANK YOU FOR ATTENTION